3D modeling of faulting around the Ou Backbone Range: implication for tectonic loading in the 2008 Iwate-Miyagi inland earthquake

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We perform 3D modeling of the faulting and tectonic loading processes around the Ou Backbone Range (OBR), northeastern Japan, using finite element analysis and taking into consideration nonlinear viscoelasticity and plasticity. We consider two major active fault zones, namely, Kitakami-Teichi-Seien and Yokote-Bonchi-Toen. These two fault zones are bounded by volcanic areas along the southern and northern edges. We consider the high geothermal gradient area below the OBR. Further, we consider very high geothermal gradient areas for the northern and southern volcanic areas. By giving a contracting deformation, we investigate the development of fault zones. Near the volcanic areas, two fault zones are created close to the center of the OBR since the brittle-viscous transition is shallow. On the other hand, in the non-volcanic area between the volcanic areas, two fault zones are generated at a small distance from the center of the OBR since the brittle-viscous transition is deep. As a result, in the non-volcanic area, the strikes of the fault zones are parallel to the OBR, but near the volcanic area, fault zones approach the center of the OBR. Near the volcanic areas, horizontal deformation zones are well developed near the brittle-viscous transition zone.

Recently, the 2008 Iwate-Miyagi inland earthquake (M7.2) occurred at the eastern foot of the OBR. The fault zone is located very close to the active volcanoes. Near the volcanoes, the depths of aftershocks are shallow and are distributed horizontally. The location of the fault zones and the shallow horizontal distributions of aftershocks near the volcanoes are consistent with our modeling results. This indicates that the generation process of the Iwate-Miyagi inland earthquake is affected by a thermal structure resulting from volcanic activity around this region.

By stopping the development of plastic deformation, we investigate the process of stress accumulation in the crust. The distribution pattern of the accumulated stress is different from that of absolute steady stress. In the volcanic region, significant stress concentration occurs just above the viscous region in the shallower crust. On the other hand, in the non-volcanic region, significant stress concentration occurs just above the viscous region in the deeper crust. Although the maximum stationary stress beneath the volcanic area is much smaller than that beneath the non-volcanic area, the maximum accumulated stress in the volcanic area is almost the same as that in the non-volcanic area. It is considered that these accumulated stress concentrations generate inland earthquakes in the seismogenic zones.